

APPARATUS AND METHOD FOR FLUID FLOW CONTROL

Cross-Reference to Related Applications

This application claims the benefit of priority of U.S. Application No.
5 60/443,323 filed January 29, 2003, which is incorporated herein by reference.

Background of the Invention

The present invention relates to control of the flow of fluids with a hydraulic valve including a flexible portion, such as including a membrane or
10 bladder, through a conduit such as a pipe, culvert, channel, drainage, stream or similar closed or open fluid carrying system.

Prior art fluid flow control devices have typically relied on motor or air-driven valves, slide gate mechanisms or inflatable dams. All of these techniques require external power and/or moving parts subject to problems such as ice
15 formation, dirt and sediment accumulation and/or power failures.

Accordingly, there is a need for a fluid flow control device and method with powerless automation, increased reliability and fewer mechanical parts.

Summary of the Invention

20 The present invention answers these needs by a providing an apparatus and method for controlling the flow of fluids with a hydraulic valve that includes an upper opening and inner containment area so a flexible portion of the valve,

such as membrane or bladder, expands the valve by "top to down" hydraulic operation into a pipe, culvert, channel or similar conveyance to restrict fluid flow.

In an embodiment of the invention a float-operated mechanical valve or other device in a containment space above the opening to the hydraulic valve
5 may be provided for adding fluid into the flexible portion of the valve causing the "top to down" hydraulic operation.

In another embodiment of the invention an overflow pipe in the containment space above the opening to the valve may be provided for maintaining a fixed level of fluid.

10 In another embodiment of the present invention, an upper plate including one or more orifices may be attached to a bladder for controlling fluid flow into the hydraulic valve. The size and number of orifices may be adjusted to control the rate of expansion and deflation.

In other embodiments of the invention, the flexible bottom of the valve may
15 be shaped to permit a minimum full-time flow through, such as a desired fixed drainage or base flow. In an alternative embodiment or complimentary embodiment, a rigid flow-through element is provided to create a full-time flow through channel between the flexible portion of the valve and conveyance. The rigid flow-through element may be a simple orifice acting to restrict flow having
20 hydraulic characteristics of increasing flow with increasing upstream head. The rigid flow-through element may be a vortex device with hydraulic characteristics of a relative fixed flow for increasing upstream head. The rigid flow-through element may be provided in two sections: the top section attached to the bottom

of the valve and the bottom section attached to or being apart of the invert of the pipe, culvert, channel or similar conveyance.

In another embodiment of the invention, the flexible portion of the valve is permitted to open and rise into the inner containment such that the pipe, culvert,
5 channel or similar conveyance has unrestricted full-flow capacity of the original pipe, culvert, channel or similar conveyance system.

It is therefore an object of the present invention to reduce or eliminate the need for an external power source or moving parts to open or restrict the flow of fluid through a pipe, culvert, channel, drainage, stream or similar conveyance.

10 It is a further object of the invention to provide a simple fluid flow control valve, such as including a bladder in certain embodiments, in which the hydrostatic pressure, and thereby the rate of opening and closing of the conveyance, can be adapted to the particular purpose or capacity of the fluid conveyance or treatment system.

15 It is a further object of the invention to provide a simple fluid control that can optimize the storage capacity of a conveyance system, for example to capture stormwater, for each and every runoff event thus attenuating downstream flow rates and minimizing system overflows or embankment erosion.

It is a further object of the invention to provide a simple fluid flow control to
20 maximize flow diversion to a secondary flow system such as a treatment system or individual treatment process without exceeding the hydraulic capacity of the secondary flow system.

It is a further object of the invention to provide a simple fluid control adaptable to existing structures or fluid conveyance systems without restricting peak capacities of the existing fluid conveyance systems.

5 It is a further object of the invention to provide a simple fluid flow control that can maintain a base flow-through and allow passage of aquatic life, where appropriate, in a fluid conveyance system.

It is a further object of the invention to provide a simple fluid control that provides periodic self-cleaning of grit, debris and other deposits from the invert of the conveyance system.

10

Brief Description of the Drawings

FIG. 1 is a schematic cross-sectional view of a fluid flow control apparatus controlling fluid conveyed from a catch basin in an embodiment of the present invention.

15 FIG. 2 is a schematic cross-sectional view of a fluid control apparatus including a flow-through opening in an embodiment of the present invention.

FIG. 3 is a schematic cross-sectional view of a fluid flow control apparatus including a flexible portion and hinge mechanism in another embodiment of the present invention.

20

Detailed Description of the Invention

The present invention provides an apparatus and method for controlling fluid with "top to down" hydraulic operation of a flexible portion of a valve secured

in a conveyance, including pipes, channels, culverts, and the like. The flexible portion may include a bladder with one or more openings at the top of the bladder. It will also be appreciated that a plurality of valves may also be used in a large conveyance.

5 Referring to FIGS. 1-2, containment space **40** is provided above the bladder portion **10** of a valve for permanently containing or adding fluid and maintaining a fixed volume of fluid in and above the bladder **10**. The bladder **10** expands and contracts based on the hydrostatic pressures of fluid within the bladder and in the upstream conveyance favoring expansion to fill and block the
10 conveyance and the fluid flowing through the conveyance until the upstream conveyance hydrostatic pressure exceeds the hydrostatic pressure within the bladder. When the upstream conveyance hydrostatic pressure exceeds hydrostatic pressure in the bladder **10**, the bladder **10** opens to relieve the upstream conveyance hydrostatic pressure until and only when it is equal to the
15 hydrostatic pressure in the bladder **10**, thereby maintaining a maximum fixed hydraulic level in the upstream conveyance.

In one embodiment of the invention, a fluid control bladder **10** is used for maintaining a flow-through dry weather base flow in a fluid conveyance system and then utilize the upstream conveyance storage capacity during wet weather
20 conditions, such as a combined sewer system or a sanitary sewer system having wet weather flow contributions. In such systems dry weather base flows are allowed to pass under the fluid control bladder **10** up to a specified design flow peaking factor. During wet weather flow conditions, the fluid control bladder

restricts the flow-through causing maximum upstream storage utilization resulting in retention and capture of wet weather flow for subsequent treatment instead of discharging from the system into receiving waters.

5 In another embodiment, the fluid control bladder **10** is used to divert flow to secondary flow streams, such as to a treatment system. In this embodiment the fluid control bladder **10** maximizes use of available upstream storage volume and thus maximizes flow to the treatment system. In a further embodiment, the fluid control bladder **10** can provide split-stream flow control by diverting flows around each level of treatment only after the capacity of the treatment process is
10 exceeded and only in an amount after available storage is utilized and for only the excess flow above the treatment process design flow rate. It can be appreciated that in such systems, split-stream flow control using the fluid control bladder **10** can maximize storage and treatment of highly variable stormwater hydrographs providing the highest treatment level available.

15 In another embodiment, the fluid control bladder **10** can be used in tributary streams or drainage ways to allow passage of base flows and aquatic biology during dry weather or slightly elevated flow conditions, while restricting higher flow rates during wet weather conditions thus attenuating downstream flow velocities by using the upstream storage capacity in the stream floodways or
20 drainage structures. In such systems in-line flow attenuation of each and every stormwater event will reduce downstream embankment erosion. It may be appreciated that this application may also allow for upstream groundwater augmentation, where appropriate.

In another embodiment, such as a flood control structure, stormwater storage basins or lake, the fluid control bladder **10** can be used to store fluid up to the maximum storage volume of the structure defined by a maximum upstream level and allow passage of only the excess flow maintaining the maximum water level yet allow excess flow up to and including the maximum capacity flow passage during peak flow conditions.

Accordingly, the present invention is particularly adapted for directing and controlling the flow of stormwater and wastewater. However, it will be appreciated that the invention may be adapted for controlling the flow, storage and diversion of fluid through a variety of conveyances. Those skilled in the art will appreciate that the present invention is adapted for use with a variety of fluids.

Referring to FIG. 1, a flexible and expandable bladder **10** is provided across a conveyance **20** such as a pipe or channel. The conveyance **20** may be either an open conveyance such as a channel or closed conveyance such as a pipe.

In exemplary embodiments the bladder **10** comprises single or multi-ply membranes of chlorosulfonated polyethylene (Hypalon), polyvinyl chloride (PVC), rubber, polypropylene, polyethylene, vinyl, neoprene, polyurethane and woven and non-woven fabrics.

The bladder **10** is positioned in the conveyance **20** being controlled so that the expanded bladder **10** completely blocks or highly restricts the flow of fluid **25** through the channel **20**. It will further be appreciated that the bladder **10** is

preferably leak-resistant and secured above the conveyance **20** being controlled so that fluid **30** used to expand the bladder does not move into conveyance **20**. Similarly, fluid **25** in the conveyance **20** is prevented from entering into or above the bladder **10**.

5 Referring to FIG. 3, in still other embodiments the flexible portion **10** of the valve may be combined with additional components, such as a hinge mechanism **85** and a plate **12** to similarly restrict the flow of fluid through the channel **20**. In this embodiment, the pressure from fluid **30** expands the flexible portion **10** of the valve downward to also actuate plate **12** downward to restrict or block the flow of
10 fluid **25** through conveyance **20**.

In embodiments of the invention, the flexible portion **10** of the valve may be opened at the top, or directly exposed to fluid **30**, to permit fluid to directly enter the flexible portion **10** and expand into the conveyance **20**. Referring to FIGS. 1 and 2, in another embodiment of the invention, the bladder **10** includes
15 an upper plate **15** for securing the bladder **10** above the channel **20**. In a further embodiment, the upper plate **15** secures to the bottom of a make-up fluid containment space **40**. Upper plate **15** includes one or more orifices **45** to allow fluid **30** from the containment space **40** to pass into and expand the bladder **10**. The number and size of orifices **45** may be adjusted so that the desired rate of
20 expansion and deflation, and thereby desired flow-through, is achieved.

In exemplary embodiments the containment space **40** includes pipe and concrete manhole, concrete structures, fiber reinforced polymer (FRP) structures, and metal structures.

In embodiments of the invention where normal operation dictates the conveyance **20** be closed to flow through, fluid, such as water, is provided in the make-up fluid containment space **40**. The fluid **30** enters the bladder **10** to restrict or completely block the flow of fluid **25** through the conveyance **20**.

5 When the bladder **10** is unexpanded, the bladder **10** deflates as a result of higher upstream hydrostatic pressure and rises up into the containment space **40** to minimize obstruction to the fluid **25** flow through the conveyance **20**.

10 In an embodiment of the invention, the depth of the fluid **30** maintained in the make-up containment space **40** is adjusted with respect to the maximum allowed elevation **50** of upstream fluid, such as in a catch basin or manhole **60** or other structure to prevent upstream flooding. In an embodiment where maximization of the use of the volume of the upstream open or closed channel or piping system is desired, the depth of the fluid **30** in the containment space **40** is approximately equal to the elevation depth **50** of the upstream fluid. The
15 maximum upstream storage volume determined by the upstream level **50** may be adjusted by setting the depth of the fluid **30** in the containment space **40**. Increasing upstream flow causing increased upstream volume and a rise above the desired upstream level **50** will result in a greater upstream hydrostatic pressure in conveyance **20** than in containment space **40** causing the bladder **10**
20 to be pushed upward releasing the fluid **25** in the conveyance **20** in an amount until level **50** is approximately equal to the depth of the fluid **30** in the containment space **40**. Accordingly, it will be appreciated that the depth of the fluid **30** in the containment space **40** can be adjusted proportional to the desired

maximum elevation **50** of the upstream fluid with only excess flow volume passing under the bladder **10** and through the conveyance **20**. The flow rate of the excess volume passing under the bladder **10** will be approximately equal to the flow into the upstream conveyance system when and after the maximum
5 volume is reached.

In one embodiment of the invention, a float-operated mechanical make-up valve **70** is provided to automatically maintain a desired fluid level in the containment space. For example, leakage and evaporation can produce water loss. Upon a drop in height, the float **75** self-activates the valve **70** to provide
10 fluid to the containment space until the preset level is restored. In embodiments of the invention, the float-operated valve **70** does not require external power. It can also be appreciated that make-up water can be provided in other ways such as electronic level measurements and other actuated valve controls or pumps for supplying make-up water.

15 In another embodiment of the invention, an overflow pipe may be provided within the containment space **40** to fix the desired depth of fluid **30**. For example, extraneous flow leakage into the containment space **40** can result in higher than desired depth of fluid **30** and thus can be expelled through the overflow pipe to maintain the desired depth of fluid **30** and thus maximum upstream level **50**. It
20 can be appreciated that make-up water supplied in excess amounts, for example, from a leaking float valve or a continuous running pump supply will be expelled through the overflow pipe without increasing the desired depth of fluid **30**. It will also be appreciated that the overflow pipe may connect to conveyance **20** on the

exiting side of the valve, or could be a pipe or channel directing the overflow to another location.

Referring to FIG. 2, a rigid spacing element **100** is provided in an embodiment of the invention to create a full-time drainage or base flow opening
5 between the bladder **10** and the conveyance **20**. In this embodiment, the spacing element **100** prevents the bladder **10** from completely blocking the conveyance **20**, and permits a limited amount of fluid **25** passing under the bladder **10** to flow through the conveyance **20**. The bladder **10** otherwise functions as described.

10 The flow-through rate through the spacing element **100** will change with increasing upstream elevation from zero to the maximum desired elevation **50** (Fig 1). In some applications there is always a base flow that must pass through the conveyance **20** and under the bladder **10**. The base flow would typically have a free surface flow as it passes through the spacing element **100**. It can be
15 appreciated that the spacing element **100** would be sized to accommodate the base flow requirements possibly including peaking factors for diurnal and /or seasonal changes as needed. The spacing element **100** can be designed to act as a simple orifice or as a vortexing orifice. In the case of the spacing element **100** provided as a simple orifice, increasing upstream level **50** will result in
20 increasing pass-through flow rates. In the case of a vortexing orifice, pass through flow rates can be limited to an approximate maximum value for increasing upstream levels **50**. It can be appreciated that in some applications,

limited base flows requiring a spacing element to be a vortexing orifice would be desirable.

In another embodiment for providing a full-time drainage or base flow, a bladder with a pre-shaped orifice, such as rubber bladder with an arched portion
5 along the bottom of the bladder **10**, is secured in the conveyance. Opposite ends of the arc portion are sufficiently spaced so that when fluid **30** enters the bladder **10**, the bladder **10** expands to block the conveyance **20**, except that the orifice created by the arched-in portion of the bladder remains. As with the use of a rigid element **100**, a full-time fluid flow-through is created.

10 In other embodiments for providing full-time drainage or base flow the spacing element **100** can be provided in the bottom of the conveyance **20** or in both the bottom of the conveyance **20** and at the bottom of the bladder **10**. It can be appreciated that having arched spacing elements **100** in either the bladder **10**, or the conveyance bottom **20** or both, will result in better automatic flushing of
15 potential accumulated debris and grit when the bladder **10** contracts due to rising upstream level **50** above the depth of fluid **30** passing excess flow under the bladder **10**.

Accordingly, while the invention has been described with reference to the structures and processes disclosed, it is not confined to the details set forth, but
20 is intended to cover such modifications or changes as may fall within the scope of the following claims.